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ADP SYSTEMS: EXAMINATION OF NON-FEDERAL HOSPITAL
INFORMATION SYSTEMS(U) GENERAL ACCOUNTING OFFICE
WASHINGTON DC INFORMATION MANAGEMENT AND TECHNOLOGY DIV

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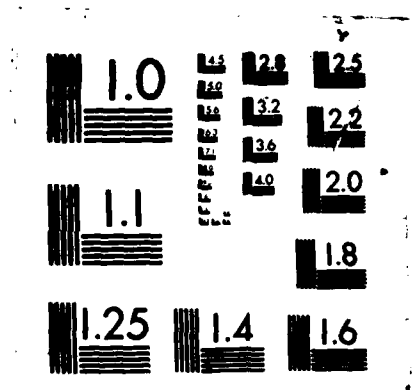
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United States General Accounting Office

Staff Study

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ADP SYSTEMS

Examination of Non-Federal Hospital Information Systems



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FOREWORD

The General Accounting Office (GAO) has been conducting a series of assignments to evaluate the efforts of the Department of Defense (DOD) and Veterans Administration (VA) to develop and install information systems in their hospitals. GAO's work has been guided by legislative requirements and the specific interests of various congressional committees. In view of the substance of these committees' interests and to properly evaluate DOD's and VA's efforts, we believed it was important to become familiar with the operational characteristics of analogous systems in non-federal hospitals and the process of implementing these systems.

This staff study includes information on the market forces which may have affected the development of commercial hospital information systems. In addition, it presents information from a GAO survey on the leading systems offered by commercial vendors and the implementation of these systems by hospitals. We believe the information in this staff study will be useful to congressional committees with oversight responsibility for DOD's and VA's development efforts. This information may also be useful to others involved with the development, selection, or implementation of hospital information systems.

The information in this staff study is presented in the format GAO used to brief various committee representatives. Briefing charts used in the GAO presentation are reproduced in this document and are followed by a narrative explanation of each chart. For additional information, please contact Mr. Melroy Quasney, the Associate Director responsible for this subject area, on (202) 275-4659.



Ralph V. Carlone
Director, Information Management
and Technology Division

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ABBREVIATIONS

DOD	Department of Defense
GAO	General Accounting Office
RFP	Request-for-Proposals
VA	Veterans Administration

SUMMARY

▲ Our purpose in conducting this study was to gain additional information about integrated hospital information systems in non-federal hospitals to be used in evaluating the Department of Defense's (DOD) and Veterans Administration's (VA) efforts to develop and implement systems for federal hospitals. We used two methods to derive the information presented in this study--a review of literature and a survey of vendors and their client hospitals. Many publications we reviewed characterized hospital information systems as being less developed than analogous systems supporting other major industries but did not present convincing quantitative data to support these characterizations. Accordingly, we conducted a series of literature searches to identify possible reasons for delays or obstacles in developing integrated hospital information systems. In addition, to acquire independent quantitative data about the most sophisticated and comprehensive commercial systems, we developed and administered a series of data collection instruments at seven of the largest vendors and client hospitals using their most technically sophisticated and comprehensive integrated hospital information systems. We also administered these instruments at the two largest hospital chains and at one hospital which had developed its own system. ←

BACKGROUND

The cost of medical care as a percentage of the nation's gross national product has doubled since 1960. In 1985, the nation's health care bill was \$425 billion--10.7 percent of the gross national product. Private health insurance, covering approximately three-fourths of the population, paid 30 percent, \$114 billion, of this country's health care costs in 1985. Federal, state, and local governments paid nearly 40 percent, \$147 billion, toward health care costs--most of which was paid by the Medicare and Medicaid programs.

In 1985, hospital and nursing home care accounted for 48 percent, \$202 billion, of the nation's health care costs. (These hospital care costs do not include charges by self-employed physicians.) Changes in calculating reimbursements made to hospitals under the Medicare program have resulted in a fixed price list of reimbursements to hospitals based on diagnosis-related groups. If a hospital is unable to keep its costs at or under the reimbursement amounts for its Medicare patients, it would have to cover the difference by

- increasing its charges paid by third party insurance (other than Blue Cross, which differs from other third party insurers because it frequently pays on a cost basis for services) and patients without insurance,
- reducing profits (if a for-profit hospital), or
- having smaller surpluses or receiving subsidies (if operated by a non-profit organization or state or local government).

WHAT ARE INTEGRATED HOSPITAL INFORMATION SYSTEMS?

Hospital administrators are looking more and more to the use of integrated hospital information systems as a means to help contain operating costs. An integrated hospital information system is a computerized communications and information handling system. It receives information from hospital departments, processes it, and maintains medical and financial records about each patient. Integrated hospital information systems make this data available hospital-wide for patient care, administrative and business management, and other purposes, such as research.

In 1980, we reported¹ that integrated hospital information systems evolved because

- hospitals must coordinate and communicate massive quantities of medical data,
- third party (excludes Blue Cross) payment systems and the Medicare and Medicaid programs have increased requirements for data to ensure the validity of claims, and
- computers can increase efficiency and reduce or contain costs through the substitution of capital equipment for costly human labor.

These systems are an outgrowth of specialized computer software programs designed for diagnostic, therapeutic, administrative, and financial purposes. These programs were integrated into information systems by several commercial firms beginning in the late 1960s and by individual hospitals through self-development efforts.

LITERATURE SEARCH RESULTS

Our literature search and related analyses revealed a number of different factors which may have inhibited the development of commercial integrated hospital information systems. (A bibliography of the articles, books, and other reports used from our literature search is included as appendix VI.) We did not attempt to independently validate these factors, measure their impact (either singly or collectively), or rank them in importance. However, we believe that from an economic standpoint, these factors may have had an impact on the development of commercial systems. These factors included:

- There is a small market for integrated hospital information systems.
- Hospitals spend a low percentage of operating revenue on automation.

¹Computerized Hospital Medical Information Systems Need Further Evaluation To Ensure Benefits From Huge Investments (GAO/AFMD-81-3, November 18, 1980).

- Historically, hospitals have not had an incentive to minimize costs.
- Many new vendors have entered the hospital information system industry and there is a high turnover of small vendors.
- Few studies have been conducted on the benefits of hospital information systems.
- Savings from these systems are currently limited to reducing the clerical work of medical professionals.
- Savings are difficult to achieve.
- Some medical personnel resist the introduction of management information technology.

VENDOR AND HOSPITAL SURVEY RESULTS

Our data collection at seven of the largest vendors showed that three different product types were identified as leading systems--an application development tool set, customized systems, and "turnkey systems". With its application (such as laboratory or pharmacy) development tool set, one vendor claims that hospitals may develop their own software with considerably less effort than that required using conventional program languages. Customized systems enable the vendor to integrate applications from various sources to form a complete system. With a turnkey system, the vendor provides hardware, software, installation, training, and other services needed before turning the system over to the hospital for operation. Many of these systems offer limited customizing, such as variable screen formats, without modifying the software. Vendors of turnkey systems will also make changes to the software at the client's expense.

Age of systems

The age of the vendors' leading systems in our survey ranged from 5 to 15 years. Each of the vendors was still supporting their system by adding new capabilities and changing its software to respond to new reporting and management requirements.

Comprehensiveness and integration

All of the systems in our survey were integrated in that they supported a variety of hospital activities and a uniform set of data access methods. The hospitals in our survey indicated that comprehensiveness (the ability to support a wide range of hospital activities) and integration (the ability to readily access all needed data for hospital functions without repetitive data entry) were the most important factors in their system selection process.

System size

The vendors' leading systems we reviewed were all less than two million lines of code. Vendors used a variety of different programming languages in their

leading systems. Annual investments in research and development by the vendors averaged \$13 million for all product developments, including custom software modifications done for individual hospitals.

Literature search confirmation

Our vendor and hospital surveys confirmed two of the conditions identified in our literature search as affecting the development of commercial hospital information systems. The literature search indicated that 200 or more beds is the optimal size for hospitals to derive significant benefits from an integrated hospital information system. In our survey, three vendors recommended their systems for hospitals with more than 100 beds, two recommended a minimum of 200 beds and two recommended 300 or more beds. Since only 30 percent of the nation's 5,732 community hospitals have more than 200 beds, the potential market for these systems is rather small. In addition, the hospitals in our survey budgeted about 3 percent of operating revenue for automation.

Implementation is difficult

Both vendors and hospitals in our survey indicated that implementing an integrated hospital information system is both a difficult and time-consuming process. All of the vendors recommended a phased implementation and indicated that it typically takes from 1 to 2 years to achieve initial operations (have at least one major application supported, e.g. admissions). The actual experience of the hospitals in our survey confirmed this point.

Hospital chains

Our examination of the leading systems of the two largest national hospital chains indicated that their systems did not support many medical information functions offered by the commercial vendors. For example, one chain used a shared financial system with limited use of stand-alone processing (not connected or interfaced with other systems) for other hospital activities. The other chain had recognized a need to modernize its existing hospital information system by replacing it with an integrated system supporting more hospital activities. This chain was planning to conduct a pilot test of a new integrated hospital information system. Because this system was not yet field-tested, we were unable to gather information about its operational performance.

Internal hospital development

The users we interviewed expressed satisfaction with the internally developed system. However, the hospital's systems personnel told us that the hospital was experiencing sharply increasing software maintenance (changing software to eliminate errors and add new capabilities) costs due to changing government and insurance reporting requirements. As a result, the hospital was in the process of replacing several major system modules it had previously developed with commercially available software.

OBJECTIVES, SCOPE, AND METHODOLOGY**OBJECTIVES, SCOPE, AND METHODOLOGY****OBJECTIVES**

- Determine the market for systems and other factors impacting the commercial hospital information systems field.
- Describe in detail exemplary installations of commercial integrated hospital information systems.

SCOPE AND METHODOLOGY

- Secondary data analysis and evaluation synthesis of published articles and surveys supplemented with expert and vendor opinions.
- Complete detailed data collection instruments for 10 vendor/hospital pairs including user assessments.

Our preliminary work on DOD's and VA's hospital system developments indicated that there was not good quantitative data to indicate the quality of commercial integrated hospital information systems, but many published assessments of these systems characterized them as not being as mature as systems supporting other large businesses. Therefore, our first objective was to identify and describe market forces that may have influenced the commercial development of integrated hospital information systems. We also wanted to describe a set of successful implementations of commercial integrated systems.

In order to obtain information about the commercial market for hospital information systems and factors which may have influenced commercial developments, we conducted a comprehensive series of literature searches. (A bibliography of the materials used in developing the results of the searches is included as appendix VI.) We supplemented this information with interviews with cognizant officials in the Department of Health and Human Services' National Center for Health Research and Assessment and analysts in the hospital information systems industry.

To identify a set of successful implementations of commercial integrated hospital information systems, we selected the leading integrated hospital information system offered by seven of the largest vendors--those which reportedly controlled 65 percent of 1984 sales. For our review, we defined a vendor's leading integrated hospital information system to be the one with the overall highest degree of functionality (activities or services supported), integration, and technical sophistication which had been marketed for at least 1 year. We also decided to

collect information from the two largest hospital chains regarding their integrated hospital information systems. Because an unknown number of hospitals use internal development as their method of obtaining integrated information systems, we selected one such hospital for our review.

We met with cognizant representatives from the vendors, hospital chains, and the hospital developing its own system to obtain, as appropriate, information on each organization's system development experience, its hospital information products and services, documented studies of hospital automation benefits, and more detailed information about leading integrated hospital information systems. For the systems identified, we used data collection instruments to obtain information on the distribution of hospitals using the system, software design, hardware and operating system requirements, and available vendor services, such as conversion services, system documentation, and training programs.

We also asked each vendor and hospital chain to identify one or more hospitals that, in their opinion, had done a good job of implementing their information system and would be willing to allow us to make a site visit to collect information on the hospital's implementation of the system. We then selected one client hospital of each vendor for a site visit. (A listing of the vendors and hospitals in our survey can be found on pp. 14 and 23, respectively.) During each visit, we obtained information describing the hospital's operations, system acquisition and installation process, related cost/benefit analyses, system characteristics (including the identification of its major functional areas), training programs, and continuing vendor support.

RESULTS OF LITERATURE SEARCH

**FACTORS CITED IN LITERATURE AS
AFFECTING THE DEVELOPMENT OF
INTEGRATED HOSPITAL INFORMATION SYSTEMS**

1. Small market for these systems (hospitals with 200 or more beds).²
2. Low levels of spending for automation in the hospital industry.²
3. Historical lack of incentive to minimize cost.
4. Many new vendors (In 1985, 152 out of 200 firms entered the field since 1983) and apparent turnover of small vendors (127 out of 175 firms in the field in 1983 had left by 1985).³
5. Limited study of cost/benefits.³
6. Savings currently limited to reducing clerical work for medical professionals.
7. Difficulty of achieving and quantifying savings.
8. Resistance by medical personnel to the introduction of management information technology (as opposed to embedded information technology, e.g., Computer Tomography, digital lab equipment, etc.).

SMALL MARKET SIZE

Several experts, as reported in trade journals and publications we reviewed, believe that 200 or more operating beds is the optimal number of operating beds needed to make efficient use of integrated hospital information systems. According to these experts, it may be practical to have lower levels of automation in smaller hospitals focusing on a limited number of independent software systems supporting activities such as accounting and billing (or finance), laboratory, and

²Confirmed by our data collection efforts at 10 hospitals, 7 of the largest vendors, 2 hospital chains, and 1 hospital with an internally developed system.

³We isolated these factors during our data collection efforts, and we believe they may have affected the development of integrated hospital information systems.

pharmacy. Table II.1 shows the distribution of the nation's 5,732 (1985 figure) community hospitals by number of operating beds. In 1985, there were 1,140 registered hospitals that were not community hospitals. These hospitals include federal, psychiatric, long-term general, and other special hospitals. Nearly 4,000, 70 percent, of community hospitals have less than 200 operating beds.

TABLE II.1

DISTRIBUTION OF HOSPITALS BY NUMBER OF BEDS

<u>Under 100</u>	<u>100-199</u>	<u>200-299</u>	<u>300-399</u>	<u>400-499</u>	<u>500 or more</u>
2589	1407	739	439	239	319

Source: American Hospital Association

The experts we cited believe most hospitals are too small to make good use of these sophisticated management information systems or, at the least, have not purchased them. Much greater markets for management information systems with higher potential sales and profits exist in many other industries. For example, literature cites mail order and catalog sales, hotels, restaurants, and department and other retail stores as all offering a greater market to software houses and vendors of value added systems. Several hospital automation industry analysts believe that the lower potential market for management information systems in the hospital industry has delayed the development and introduction of more sophisticated systems which may be found in other industries.

LOW LEVELS OF SPENDING

Another factor cited in literature as limiting the market for integrated hospital information systems is low levels of spending by hospitals for data processing as a percentage of gross revenues. Several surveys reported in trade journals and publications indicate that hospitals generally invest only 1 to 1 1/2 percent of gross revenues on automation. These percentages had relatively little dependence upon the size of the hospitals.

HISTORICAL LACK OF INCENTIVE TO MINIMIZE COSTS

Literature cites as a possible cause for these low levels of spending for automation the historical lack of price competition, or other strong incentives to reduce or contain costs in the hospital industry. Another possible contributing factor cited was the non-profit and government supported status of many hospitals. As noted in literature, an information system is generally the second largest investment a hospital may make (only the physical plant is more costly). It may be very difficult to raise funds for this purpose. Also, information systems are investments with high first year costs that are difficult to meet with the limited ability of government and non-profit hospitals to raise these funds. In contrast, physical plant expenditures can be spread out over a number of years by building in smaller increments to meet evolving needs.

MANY NEW VENDORS AND HIGH TURNOVER

In 1985, there were more than 150 vendors with sales of less than \$10 million. We compared the listings of vendors contained in the 1985 Dorenfest study⁴ with a 1983 study⁵ performed by Deloitte Haskins-Sells for VA. The studies used different methods to attempt to comprehensively identify the universe of firms selling hospital information systems. The VA study identified 175 vendors, 23 of which offered two or more of the six most prevalent modules (Finance, Nursing Station Automation, Pharmacy, Laboratory, Radiology, and Admissions/Discharge/Transfer) found in integrated hospital information systems. The Dorenfest study identified 200 firms, 73 of which offered two or more of the six most prevalent modules.

Of the 175 vendors identified in the VA study, only 48 were also found in the Dorenfest study. While we are aware that there have been a number of mergers and takeovers, it is possible that many of the 127 vendors not found in the Dorenfest study are no longer in the hospital information system industry. For example, the Dorenfest study identified 33 firms as having left the industry since 1983. We did not attempt to determine what happened to the other vendors not listed in the 1985 Dorenfest study. Conversely, the Dorenfest study listed 152 vendors which were not identified in the 1983 study. In all, only 48 vendors were identified by both studies. Interestingly, 36, 75 percent, of these 48 firms were identified as having two or more of the six most prevalent modules in the 1985 Dorenfest study.

LIMITED STUDY OF COST/BENEFITS

We found few studies that actually attempt to measure the costs and benefits of implementing integrated hospital information systems. In 1980, we reported⁶ that there was limited evidence to indicate that the billions of dollars that hospitals were poised to spend on integrated systems would result in cost savings to hospitals. At that time, the only study of cost benefits indicated that system costs exceeded system savings. There are, in addition to savings that can be quantified, qualitative benefits which may accrue to hospitals. Since 1980, we have been unable to find any new studies to resolve the issue of whether these systems can reduce hospital costs sufficiently to justify their expense.

⁴Business Opportunities In The Hospital Computer Market, Sheldon I. Dorenfest & Associates, LTD., 1985.

⁵[Report on] HIS Data Collection and Validation Methodology, Deloitte Haskins-Sells, March 21, 1983.

⁶Computerized Hospital Medical Information Systems Need Further Evaluation To Ensure Benefits From Huge Investment (GAO/AFMD-81-3, November 18, 1980).

SAVINGS RELATE TO REDUCING MISCELLANEOUS CLERICAL TASKS

Literature cites that the savings that can accrue from integrated hospital information systems are most likely to come from reductions in the time required for medical personnel to perform clerical tasks. These tasks include filling out, transporting, transcribing, correcting, storing, tracking, and retrieving paperwork. Estimates found in literature indicate that medical professionals spend up to 25 percent of their time performing these clerical tasks. Only a fraction of this time can be saved by automation. According to several industry experts, the bulk of labor savings are most likely to occur piecemeal across many departments, shifts, and labor categories.

DIFFICULTY OF ACHIEVING AND QUANTIFYING SAVINGS

Literature indicates that because time savings are highly fragmented, they must be combined or consolidated to reduce the number of personnel or the hours worked. In practice, this is difficult to do and requires a concerted effort. According to the Chief of Health Information Systems for the National Center for Health Services Research, few hospitals achieve the potential benefits available from their integrated hospital information systems.

Most industry consultants and hospital administrators agree that the motivation for acquiring an integrated hospital information system is not limited to only cost savings. Another category of real benefits are qualitative. These benefits include improvements in patient relations, better information for physicians, improved timeliness of information, reduced opportunity for error, better control of charges, and improved management information. These benefits are intangible and difficult to translate into economic terms. There are indications that the improved timeliness achieved through integrated hospital information systems may shorten the length of stay of patients by shortening the turnaround time for ancillary services. The cost savings implications of changes such as these have not been tied conclusively to automated information handling.

RESISTANCE BY MEDICAL PERSONNEL

User resistance can undermine the most powerful, attractive, and economical automated information system. While many medical professionals have embraced the introduction of management information technology, we found several citations during our literature search indicating that hospital personnel may resist or interfere with the implementation of integrated hospital information systems. To achieve additional benefits from medical information systems in the future, some experts believe that these systems must include computerized processing (as opposed to merely recording) of medical information to assist physicians in making clinical decisions. Clinical applications of computer technology have not yet met with wide, general acceptance from physicians. Physicians have a unique relationship to hospitals because doctors are the prime decision makers and meeting their needs is a fundamental requirement of hospital activity. One

comprehensive study of medical information systems by a prominent systems analysis firm⁷ notes that physicians who feel that the implementation of a hospital information system is improperly diverting their time and efforts can effectively resist by threatening to leave and take their patients (business) elsewhere.

⁷Hospital Information Systems: A State-Of-The-Art Report, MITRE Corporation, May 1982.

RESULTS OF DATA COLLECTION FOR LEADING INTEGRATED HOSPITAL INFORMATION SYSTEMS

SCOPE OF DATA COLLECTION FOR LEADING INTEGRATED HOSPITAL INFORMATION SYSTEMS

- Two largest hospital chains
- One hospital internal development
- Seven of the largest vendors and client hospitals

To gain broad coverage of possible system acquisition methods, we selected the two largest hospital chains, one hospital with an internally developed system, and seven of the largest vendors. We selected the two largest hospital chains because a hospital chain, in terms of organization, most closely parallels federal hospitals operated by DOD and VA. The hospital chains, DOD, and VA have central management of many functions including information systems. We selected one hospital with an internally developed system which is an alternative to purchasing an off-the-shelf (already developed and available for purchase) system. We also selected seven of the largest vendors which were reported⁸ to have approximately 65 percent of 1984 sales.

TWO LARGEST CHAINS AND THEIR HOSPITAL INFORMATION SYSTEMS

- One chain uses a shared financial system with limited use of stand-alone processing for other functions
- The second chain has recognized its existing system is not integrated and planned to pilot test a new system

We visited the two largest hospital chains to find what type of computer systems they had and how they selected and managed the installation of their systems. We found that one chain, with more than 400 hospitals, relied on a shared financial system with data processing at a single location. Its hospitals batch their

⁸Business Opportunities In The Hospital Computer Market, Sheldon I. Dorefest & Associates, LTD., 1985.

transactions daily for overnight processing at their central data center. This hospital chain also used stand-alone processing (where the processor is at the hospital and is not connected to the main system) for other functions at some hospitals. Most of these stand-alone systems were for an admissions/discharge/transfer system and a diagnosis-related group system.

The second hospital chain, composed of 86 hospitals, was replacing its existing automated system with a fully integrated system offering greater functionality. (With systems that are not integrated, each separate processing area, such as laboratory, pharmacy, and finance, uses independent data bases which require some duplication of data.) This hospital chain acquired this system from a commercial vendor but, on its own, had made numerous changes to the software and, therefore, the hospital chain was responsible for maintaining the software. It was in the early stages of acquiring a new system from a commercial vendor and had not, at the time of our effort, begun a pilot test of the prospective system.

THE INTERNALLY DEVELOPED
HOSPITAL SYSTEM

-- Well-accepted by its users

BUT

-- Maintenance costs are increasing rapidly

-- Several major application modules are being replaced with off-the-shelf software

Users of the internally developed system that we interviewed expressed satisfaction with it. The system began operations in 1977 and the hospital was continuing to develop new applications. However, the hospital's systems personnel reported that software maintenance costs for existing applications were escalating because of many changes in reporting requirements for federal programs and third party insurers. As a result, the hospital was planning to acquire off-the-shelf software for several major functional areas to replace software it had developed earlier. These replacement applications would then be integrated with the remainder of its system.

**SEVEN OF THE LARGEST VENDORS AND
THEIR LEADING INTEGRATED SYSTEMS**

<u>Vendor</u>	<u>System</u>
Burroughs	Burroughs Health Information System (BHIS)
Compucare ⁹	Distributed Management Application System (DMAS)
HBO	MEDSTAR
IBM	Patient Care System (PCS)
McDonnell-Douglas	Patient Care System (PCS)
SMS	Independence
Technicon	Medical Information System (MIS)

We asked the vendors to select their system which had the highest degree of technical sophistication and greatest functionality. Various kinds of products were designated as leading systems by the vendors. IBM's PCS is a set of software tools and includes an application development language for hospitals to use in developing their own customized system. However, hospitals could elect to use applications developed by the vendor, other hospitals, or third parties. Compucare, a division of Baxter-Travenol, provides custom integration services as its leading product. With the assistance of Compucare, hospitals may choose applications developed for stand-alone use or as part of other integrated systems. Compucare then integrates these products for the hospital. The other five vendors offer turnkey systems with custom modifications. With a turnkey system, a vendor will install hardware and software and provide training to users and operators. After a vendor installs a turnkey system, the hospital assumes responsibility for system operations and maintenance. With a turnkey system purchase, a hospital should need little or no in-house data processing expertise prior to system installation. Many turnkey vendors also offer continued software maintenance, including new software releases for an additional charge.

⁹Division of Baxter-Travenol

VENDOR INFORMATION**ORIGINAL RELEASE DATES OF
LEADING SOFTWARE SYSTEMS**

<u>Year</u>	<u>Number of Systems</u>
1971	One
1974	Two (One system was reprogrammed and redesigned in 1984)
1978	Two
1980	One
1981	One

The leading systems selected by the vendors have been installed in hospitals for 5 to 15 years. The average time from their first installation is 9 years. Each of the systems was still being supported in terms of adding new capabilities and incorporating changes to respond to evolving government and insurance company requirements.

**VENDOR ANNUAL RESEARCH AND
DEVELOPMENT COSTS FOR
HOSPITAL INFORMATION SYSTEMS**

Range	=	<u>\$3 million to \$34 million</u>
Average	=	<u>\$13.3 million</u>

We asked the vendors to provide their annual research and development expenditures for hospital information systems. Generally, this includes new developments and maintenance of existing products. It also includes the costs for making software changes at the request of individual hospitals. The vendors averaged \$13 million and their individual expenditures ranged from \$3 million to \$34 million per year. One vendor could not provide information on its research and development efforts.

**HOW LEADING SYSTEMS
WERE INTEGRATED**

- 3 Common data base
- 4 Common data base with partially distributed data
- 0 Totally distributed data

We asked each of the vendors to categorize how their leading systems were integrated. Three vendors integrated their system by using a common data base and four used a combination of a common data base and partially distributed data to integrate their system. With a common data base, all application software is written against a collection of organized data to avoid duplication of data. When part of the data is distributed in separate files, additional software must be written to access data and there will be some duplication of data. This may be useful when certain data is only used by a single department. Five of the vendors described integration in functional terms. That is, the system is integrated if all system data is available to an authorized user and the same data access methods are supported for all data.

PROGRAMMING LANGUAGES USED

<u>Language</u>	<u>Vendor</u>							<u>Total</u> ¹⁰
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>	
Cobol		X		X		X	X	4
Assembler				X	X		X	3
P/L 1				X				1
MUMPS	X		X					2

The vendors used a variety of programming languages. COBOL and P/L 1 are commonly referred to as third generation languages. Third generation languages use a variety of English-like statements which simplify programming. Most systems

¹⁰Totals to more than seven because one vendor used three languages and another used two languages.

today are written in third generation languages. MUMPS (Massachusetts General Hospital Utility Multi-Programming System) is a third generation programming language developed originally for building medical systems. MUMPS is being used by the VA in its Decentralized Hospital Computer Program. Assembly languages are frequently called second generation languages. Assembly languages are closer to machine language than third generation languages. As noted, two vendors used more than one programming language.

SOFTWARE SYSTEM SIZE DISTRIBUTION

<u>Lines of Code</u> <u>(in thousands)</u>	<u>Number of</u> <u>Systems</u>
500 - 1,000	3
1,001 - 1,500	1
1,501 - 2,000	2

The vendors' leading systems varied in size (lines of code). None of the systems were longer than 2 million lines of code. One vendor was unable to provide the size of its system because its product, custom integration of stand-alone applications and modules from other integrated systems, does not have a fixed number of lines of code.

**VENDOR MODIFICATION OF
SOFTWARE AT CUSTOMER REQUEST**

<u>Number of Vendors Willing to Modify</u>	<u>Percent of Source Code Modified</u>
2	None
0	5 - 10%
5	Over 30%

The vendors split into two groups concerning their willingness to modify their leading systems at customer request (and expense). Two vendors indicated that they do not make changes to the software for their client hospitals. Five vendors indicated that they were willing to modify 30 or more percent of the source code written by programmers. Essentially, these vendors were willing to make any changes to the source code at the customer's expense. Most of the systems provide client hospitals with the capability to make limited changes, such as screen formats, without any assistance from the vendor.

**MINIMUM HOSPITAL SIZE RECOMMENDED
BY VENDORS FOR LEADING INTEGRATED SYSTEMS**

<u>3</u>	100 or more beds
<u>2</u>	200 or more beds
<u>2</u>	300 or more beds

We asked each of the vendors to indicate the minimum size of hospitals, in terms of number of beds, for which it might recommend its leading system rather than another, more limited product. Three vendors indicated 100 beds, two vendors indicated 200 beds, and two vendors indicated 300 beds. The results of our literature search indicated that, as a general rule, hospitals need to have 200 or more beds to derive significant benefits from a large-scale integrated hospital information system.

**DISTRIBUTION OF VENDORS'
LEADING SYSTEMS INSTALLED
IN HOSPITALS BY NUMBER OF BEDS**

<u>Number of Beds</u>	<u>Number of Hospitals</u>
Under 100 -----	22
100 - 200 -----	106
201 - 300 -----	96
301 - 400 -----	105
401 - 500 -----	103
Over 501 -----	<u>95</u>
	TOTAL 527

We asked each vendor to provide the distribution by bed size of its customers using its leading system. The results provide further support that these systems are more likely to be used by larger hospitals of 200 or more beds. Hospitals with less than 200 beds represented about 70 percent of community hospitals in 1985, but make up less than one-fourth of the client hospitals reported by the vendors.

**VENDOR RECOMMENDATION AND
TYPICAL TIMES FOR SYSTEM
INSTALLATION OR CONVERSION**

7 Vendors Recommended Phased-In Implementation¹¹

<u>Typical Installation Times</u>	<u>Vendor</u>
<u>(In Months)</u>	
2 to 18	D
6 to 24	G
6	A
12 to 14	B
12 to 24	F
18	E
24	C

Ave. minimum time: 11.4 months

Ave. maximum time: 18.3 months

We asked the vendors to provide information on the typical installation methods and time required to implement their leading systems. All of the vendors recommended a phased installation where initial system operations include only a few applications. Additional applications are added later as the hospital is ready to install them. Generally, it takes about a year or more of effort to achieve initial operations. Major variables cited by the vendors as affecting system installation are the commitment of hospital management and the capabilities of hospital personnel to absorb the inevitable disruption.

¹¹One vendor also recommended a one-time conversion in some cases.

APPLICATION AREAS SUPPORTED BY VENDORS ¹²								
Application Area	Vendor							
	A	B	C	D	E	F	G	TOTAL
Patient Registration System	X	X	X	X	X	X	X	7
Admission/Discharge/Transfer System	X	X	X	X	X	X	X	7
Order Entry and Results Reporting	X	X	X	X	X	X	X	7
Nursing Services System	X	X	X	X	X	X	X	7
Pharmacy System	X	X	X		X	X	X	6
Radiology System	X	X	X		X	X	X	6
General Management Reporting System		X	X	X	X	X	X	6
Clinical Laboratory System	X	X	X		X	X	X	6
Central Scheduling System	X	X	X		X	X	X	6
Medical Records Tracking System		X	X		X	X	X	5
Medical Records Maintenance System		X	X	X	X		X	5
Ambulatory Care Services System		X	X		X	X	X	5
Operating Room System		X	X	X		X	X	5
Cost Accounting and Budgeting System		X	X			X	X	4
Computerized Medical History System	X	X	X		X			4
Radiation Therapy System		X	X		X	X		4
Nuclear Medicine System	X		X		X	X		4
Nursing Home System		X	X				X	3
Dietetics System		X			X		X	3
Mental Health Services or Counseling System			X		X			2
Fee Basis Reporting System			X					1
Rehabilitation System					X			1
Dental Service or Dental Laboratory System								0
Domiciliary System								0
TOTAL APPLICATIONS SUPPORTED	10	18	20	7	18	15	16	--

¹²Developed by a contractor during a 1983 VA study.

We asked each vendor to indicate which application areas its leading system supported. We derived this listing of 24 application areas from a 1983 contractor study conducted for the VA. The results show considerable variations in terms of application areas supported. While several systems covered a majority of the applications, none covered them all. The average number supported was about 15. Generally, it would not be appropriate to automate every application area in a single hospital. In several application areas, such as mental health services and dental services, there may be insufficient volumes of activity at many hospitals to warrant the additional costs of automation.

**THERE IS NO CONSENSUS AMONG
VENDORS ON WHERE SAVINGS ARE ACHIEVED¹³**

- | | |
|----------|---|
| <u>4</u> | Cited capturing lost charges |
| <u>5</u> | Cited reducing time for clerical tasks of medical professionals |
| <u>3</u> | Cited improved management control |
| <u>1</u> | Cited no areas for savings |

We asked each vendor to identify areas where hospitals could reasonably expect to generate savings. Four vendors cited the capturing of lost charges. Lost charges occur with more limited or manual systems where patient services may be delivered but the patient's bill does not capture the charge. Essentially, these are bookkeeping errors. It should be noted that capturing lost charges does not reduce operating costs, but can increase hospital revenue from some patients (those with third party insurance and those paying out of pocket).

Five vendors cited a reduction in time for medical professionals to complete tasks that are inherently clerical in nature. This time gained could be used to provide additional patient services or accumulated to reduce the number of hospital personnel and, therefore, reduce the hospital's payroll.

Three vendors cited improved management control as an area for savings. These savings could be achieved by better management of the hospital's personnel, equipment, and supply inventories.

One vendor said that there were no areas where savings could be predicted, but that its hospital information system allowed hospital operations to run more smoothly.

¹³Totals to more than seven since some vendors cited more than one area of savings.

HOSPITAL INFORMATION**HOSPITALS VISITED DURING
GAO SURVEY**

<u>Hospital</u>	<u>Number of Beds</u>
St. Lukes, Bethlehem, PA	442
Univ. of Tennessee, Knoxville, TN	535
Loma Linda Univ., Loma Linda, CA	546
Parkview Memorial, Fort Wayne, IN	654
Waukesha Memorial, Waukesha, WI	290
Charlotte Memorial, Charlotte, NC	825
Univ. of Wisconsin, Madison, WI	548

We obtained information from seven hospitals identified by commercial vendors as using their leading integrated hospital information systems. These hospitals varied in size from 290 beds to 825 beds. Annual hospital operating budgets ranged from \$41 million to \$200 million. The hospitals spent an average of 3 percent of budget for data processing.

We found three types of hospital ownership. Two hospitals were owned by local governments, two were state owned, and three were privately owned not-for-profit hospitals. None of the hospitals used professional hospital management firms.

<u>ELAPSED TIME NEEDED FOR SYSTEMS TO BECOME OPERATIONAL¹⁴</u>			
<u>Hospital/Vendor</u>	<u>Contract Signed</u>	<u>First Operation</u>	<u>Total Time/Months</u>
A	09/82	03/83	6
B	04/83	10/83	6
C	10/83	05/84	7
D	06/79	11/80	17
E	11/79	10/80	11
F	11/80	10/82	23
G	10/82	12/82	2
Average time = 10.3 months			
Range: = 2 to 23 months			

The hospitals we visited averaged 10 months from contract signing to initial operations; that is, the point in time when at least one system application is operating. Actual time ranged from 2 to 23 months. These results corresponded with the typical installation times indicated by the vendors.

HOSPITAL SYSTEM SELECTION PROCESS

- Six hospitals conducted user requirements analyses
- Five hospitals used RFP's

We asked each of the hospitals whether they had prepared user requirements analyses and Requests-for-Proposals (RFP). Six hospitals conducted user requirements analyses and five used RFPs. User requirements analyses delineate

¹⁴At least one system application in operation.

the functions which the automated system should support. We have found that defining user requirements is an important part of acquiring and developing systems. Omitting this step can result in acquiring systems that do not meet user requirements, or systems that provide capabilities that are not needed. RFPs describe the mandatory and optional system characteristics that are desired. RFPs are useful because they result in soliciting responsive proposals and obtaining competitive terms on prices.

Five of the six hospitals that conducted user requirements analyses involved hospital department users, such as nurses and technicians. The other hospital contracted with a consultant to prepare the analysis.

Five hospitals issued RFPs to identify prospective vendors for detailed evaluation.

**HOSPITALS CITED THE FOLLOWING
SELECTION FACTORS IN RANK
ORDER OF IMPORTANCE**

<u>Factor</u>	<u>Rating By Hospital</u>						
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>	<u>G</u>
Comprehensiveness and Integration	5	3	5	5	5	5	4
Reliability	5	3	5	5	5	4	4
Flexibility	4	5	5	4	5	4	4
Strength of Vendor	3	3	5	5	4	4	4
Cost	3	3	5	3	5	4	4
Implementation Plan/Support	4	3	5	5	4	2	3
Depth of Functionality ¹⁵	2	5	4	3	5	4	3
Technological Sophistication	2	3	5	5	3	3	4
Performance	5	3	4	4	5	3	1
Maturity	3	3	3	1	4	3	1

Rating Scale

- 1 - Little or no Importance
- 2 - Somewhat Important
- 3 - Moderately Important
- 4 - Very Important
- 5 - Critical

We asked each hospital to rate the importance of ten different factors in their selection of a hospital information system. We then constructed an ordinal ranking using the composite score of each factor derived from the hospital ratings. The

¹⁵For example, while entering a patient's prescription, does the system update the patient's medical and financial records, check for adverse drug interactions, identify unusual dosages, update the pharmacy's inventory records, etc.?

hospitals as a group considered comprehensiveness and integration as the most important factor in their selection. Other attributes, such as reliability, flexibility, and cost were also considered to be highly important.

REPORT PRODUCTION CAPABILITIES
REPORTED BY HOSPITALS

- All seven systems can generate periodic reports
- All seven systems can generate ad hoc reports
- Two systems do not require programming support
- Five systems require programming support

We asked each hospital to describe the ability of its system to generate periodic and ad hoc reports. All seven hospitals had facilities for the creation of periodic reports.

All of the hospitals were able to create ad hoc reports. However, only at two hospitals could these reports be created by users without programmer support. The ability of users to create ad hoc reports without programming support relieves the programming staff of disruptions and allows users direct access to information.

APPLICATION AREAS AUTOMATED BY HOSPITALS ¹⁶								
Application Area	Vendor							
	A	B	C	D	E	F	G	TOTAL
Patient Registration System	X	X	X	X	X	X	X	7
Admission/Discharge/Transfer System	X	X	X	X	X	X	X	7
Order Entry and Results Reporting	X	X	X	X	X	X	X	7
Radiology System		X	X	X	X	X	X	6
Clinical Laboratory System	X		X	X	X	X	X	6
Medical Records Maintenance System	X		X	X	X	X	X	6
Dietetics System		X	X	X	X	X	X	6
Radiation Therapy System		X	X	X	X	X	X	6
Pharmacy System	X		X	X	X	X		5
General Management Reporting System	X			X	X	X	X	5
Medical Records Tracking System	X		X	X	X			4
Ambulatory Care Services System				X	X	X	X	4
Nuclear Medicine System				X	X	X	X	4
Rehabilitation System		X	X		X		X	4
Computerized Medical History System		X		X	X		X	4
Nursing Services System		X		X	X	X		4
Cost Accounting and Budgeting System	X		X	X				3
Operating Room System				X		X	X	3
Fee Basis Reporting System	X			X				2
Mental Health Services or Counseling System					X			1
Central Scheduling System					X			1
Nursing Home System								0
Dental Service or Dental Laboratory System								0
Domiciliary System								0
TOTAL APPLICATIONS SUPPORTED	10	9	12	18	18	14	14	--

¹⁶Developed by a contractor during a 1983 VA study.

We asked each hospital which of the 24 application areas were supported by automated systems, including any systems provided by other vendors or internally developed. We found considerable variation in the applications automated at the seven hospitals.

None of the hospitals we visited had automated all 24 applications areas. The hospitals automated from 10 to 18 applications with an average of 14 automated applications. The hospitals' use of software applications for many purposes is in concert with the first ordinal ranking of comprehensiveness and integration as a system selection factor.

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